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DISCOVERY OF MARINE JURASSIC ROCKS IN SOUTHWESTERN TEXAS.

SEVERAL announcements of marine Jurassic rocks in New Mexico and Texas have been made by authors, the earliest as also the latest by Mr. Jules Marcou ; but the marine sediments hitherto called Jurassic in these states belong to the Comanche series. *Modiola jurafacies*, *Homomya jurafacies*, *Exogyra hilli*, and possibly one or two other members of the fauna of the latter series, which are more or less clearly analogous with fossils of the European Jurassic, should doubtless be regarded as survivals from a preceding age. Such survivals are only to be expected, and these therefore do not contradict the results arrived at by Professor R. T. Hill and Mr. F. H. Knowlton, who have shown that the lowest formation of the Comanche series presents a Wealden fauna and flora. The data of old-world stratigraphy seem to show that the Wealden formation is part of the Cretaceous system, or, more definitely, is the estuarine and arenaceous extension of lower Neocomian sediments that are elsewhere of purely marine origin and largely calcareous.

It is a principle recognized by many geologists that where the conditions afford only palæontological data for correlation and these data show a commingling of fossils of two successive systems, we should not suppose that the latest occurrence of fossils of the earlier system characterizes the highest rocks of that system, but should assume that *the first appearance of a fauna essentially characteristic of a later system, whether it be accompanied by survivals from an older fauna or not, marks the beginning of a new rock-system and age*. By this criterion Professor C. S. Prosser of the United States Geological Survey has recently drawn the line separating the Permian system from the Carboniferous in the Plains region ; and in accordance with the same principle, if the prevalent European acceptance of the Cretaceous system

be adopted for America, the entire Comanche series belongs to the Cretaceous.

No true Jurassic of marine origin, therefore, has hitherto been recognized in the southern part of the United States.¹

In 1893, when studying the Cretaceous fauna of Texas, as represented in the museum of the Geological Survey of that state, I was led to suspect the occurrence of Jurassic rocks in the vicinity of Malone, a flag-station of the Southern Pacific railway between El Paso and Sierra Blanca Junction. The evidence of such possible Jurassic formation was derived from the study of a small collection of Mesozoic fossils that had been obtained by Messrs. W. H. von Streeruwitz and Ralph Wyschetzki, according to the field-labels, "in hills about a mile northeast of Malone." The collection, though small, revealed a fauna quite different from any known in the North American Cretaceous, and one which, it was therefore surmised, might be pre-Comanche. All of the material that was deemed sufficient for study was treated of in the writer's "Contribution to the Invertebrate Palæontology of the Texas Cretaceous," in the Fourth Annual Report of the Texas State Geological Survey. It included six species, all apparently new to science, which were described under the following names: *Anatina tosta*, *Cucullæa transpecosensis*, *Cyprina* (? *Roudairia*) *streeruvitzii*, *Trigonia wyschetzskii*, *T. taffi*, and *Venus malonensis*. These fossils threw little light on the question of Jurassic or Cretaceous age of the rocks in which they occurred, as all of the genera were known to be common to both of these geological systems, and the two species of *Trigonia* were regarded as presenting features that allied them to both certain Jurassic and certain Cretaceous trigonias. The problem was therefore left unsolved.

Besides the Malone hills, the only locality where any fossil

¹ The Morrison Formation (Cross) of Colorado and Wyoming was traced along the front of the Rockies many years ago by Dr. F. V. Hayden at least as far south as Las Vegas, and its occurrence at the latter point has been recently confirmed by Professor Alpheus Hyatt. But this, though it has usually been called Jurassic, is now beginning to be regarded by some as probably lower Cretaceous (Wealden), and, whatever its age, is a fresh-water formation.

purporting to belong to the same fauna had been collected was Bluff mesa, upon which Mr. J. A. Taff of the Texas Survey had obtained part of the type-material of *Trigonia taffi*, the remainder being labeled as from the Malone locality. The rocks of Bluff mesa having been referred by Mr. Taff to the "Washita division"¹ (though the fossils he named from them were Glen Rose species) there was literary evidence that seemed to connect the Malone fossils with the Comanche series. Awaiting further light, they were therefore left among the fossils of that series. The "Washita" intended by Mr. Taff included both the true Washita, as originally established by Dr. B. F. Shumard under the name, Washita limestone, and the Denison formation of Professor Hill.

I did not, however, feel satisfied with this disposal of them, and I determined to reëxamine the matter at the earliest opportunity. This came in a journey made to Guaymas, Mexico, in the spring of 1895, by my friend, Mr. Robert W. Goodell, who, at my request, and assisted by his father, Mr. R. R. Goodell, very kindly made a side trip to the Sierra Blanca Mountains and the Malone hills to obtain further collections and data from those localities. From the Sierra Blanca Mountains, one of the localities of Comanche rocks nearest to the Malone hills, the Messrs. Goodell brought back many species of Mesozoic fossils, all of them apparently from Comanche rocks, most of them Washita forms, and many of them profusely abundant, but not one of them identical with fossils of the Malone hills. The Goodell collections from the Sierra Blanca Mountains and the Malone hills not only emphasized the distinctness of the fauna of the latter locality from that of the Comanche series, but they also settled the age of the Malone fauna. For, from the Malone hills they included, besides three of the species collected there by earlier explorers, several other forms, all of which seemed to be new to science,² and one of which was a

¹Second Annual Report of the Geological Survey of Texas, pp. 719, et seq., and Plate XXVII.

²Since this was written, two of these forms have been found to be probably identical with two fossils that have been described from the Jurassic of Mexico. See footnote relating to *Pleuromya* and *Lucina*.

Trigonia of the section, *Undulata*, a type exclusively characteristic of Jurassic rocks. This beautifully ornamented shell is of medium or smaller than medium size in the genus, ovate, strongly inflated, and has the partly continuous and partly tuberculated ribs abruptly angulated. I have named it, after Mr. Robert W. Goodell, *Trigonia goodellii*. Moreover, a careful reëxamination of *Trigonia vyschetskii*, made possible by the new material in the Goodell collection, indicated that it belonged to the *Clavellata* section of its genus, a section chiefly of Jurassic occurrence. As *Trigonia* is, among lamellibranchs, relatively important as a means of stratigraphic diagnosis, and as none of the Malone fossils agreed with species known in the lower Comanche, the evidence from the Goodell collection has led me to refer the Malone fauna and formation to the Jurassic system.

The vicinity of Malone was visited but once by the Messrs. Goodell (March 30, 1895), and then for only part of a day, their journey thither having been made from Sierra Blanca by wagon.

I am indebted to the kindness of Mr. Robert W. Goodell for the use of his field notes on the Sierra Blanca region, and particularly for those on the Malone hills, which include a section across the latter at a point considerably west of that at which Mr. R. R. Goodell collected the fossils and presenting different but apparently related conditions. His Malone hills notes are as follows:

A careful search of the western end of the line of hills one mile N. E. of Malone failed to reveal any fossils. The following is a section across the western end of this line of hills.

Bearing [magnetic] of line from station to beginning of section-line, N. 70° E.

Bearing [magnetic] of section-line, N. 20° E.; one-half mile from station. [Malone station.]

1) 340 feet heavily bedded limestone; no fossils; seams of calcite abundant; dip——; labeled M.

2) 30 feet coarse gypsum; dip 75° S. 40° W.; labeled N.

3) 10 feet laminated gypsum; dip 75° S. 40° to 50° W.; labeled O.

4) 50 feet red grits interspersed with seams of gypsum of various widths; dip 75° S. 40° to 50° W.; labeled P.

5) 110 feet coarse gypsum, same as N.

6) 450 feet heavily bedded limestone, with many seams of calcite which in places are several feet wide. That is, there are places several feet wide where there is more calcite than limestone. Dip hard to get, but at one place halfway across the bed it was 75° N. 40° E.; labeled Q.

General direction of hills nearly E. and W. The water has worn out a little draw in the gypsum beds between the limestone.

Several hundred yards west of where this section was made, at the extreme N. W. end of these hills, near the R. R., is an outcrop of soft sandstone. Parties have opened this up in one or two places, in search of fossils perhaps, but I could find no trace of any.

About a mile east of where I made this section, between the last two hills of this series, R. R. Goodell found an outcrop carrying fossils; a large clam, a *Trigonia* with rough nodular ridges, and two other bivalves. Outcrop 500 feet long, 150 feet wide; strike N. and S.; dip about 20° E.

Instead of four species of bivalves, however, the collection which the Messrs. Goodell brought back from this locality included seven, besides a fragment of an eighth and one of an ammonite. The bivalves included *Pholadomya tosta* (which the Goodell collection showed had been erroneously referred to the genus, *Anatina*); *Trigonia vyschetskii*; the new *Trigonia* of the Jurassic section *Undulatae*, *T. goodellii*; a subcircular, strongly compressed shell which is either a *Cyprimeria* or a *Lucina*, and to which I have given the MS. specific name *metrica*, from its being ornamented with concentric, sharply raised lines disposed at ample and remarkably regular intervals; a plain or gently and irregularly concentric-undulate, elongate *Pleuromya*—*P. malonensis* of my MS.,¹ showing in several examples the overlapping of the left hinge-margin by the right, characteristic of this genus; the *Venus malonensis*; an indeterminate ostreid (shown only in section, imbedded); and a fragment of another shell, possibly a *Trigonia* of the section, *Costatae*. The *Pleuromya* bears more or less resemblance to *P. henseli* Hill, a Glen Rose species which the writer has collected at a number of localities

¹ Since this and the preceding species were studied, drawn, and named, I have recovered a mislaid copy of Castillo and Aguilera's "Fuana Fossil de la Sierra de Catorce" (Boletin de la Comision Geologica de Mexico, Num. 1), and it seems to me that there can be little doubt of their belonging respectively to the *Pleuromya inconstans* and *Lucina potosina* of those authors.

in north-central Texas and which is especially abundant in Hamilton county of that state. Specimens of both species, as usually preserved, vary somewhat in shape owing to mechanical distortion, and it is difficult to determine their precise natural form. Apparently, however, the Malone species differs from the *P. henseli* in having its posterior portion less tapering and a little recurved. The ammonite fragment did not show the suture; but the form and ribbing indicate a type common in the upper Jurassic.

As shown by the the rock adhering to fossils in the Goodell collection, the fossiliferous strata of the Malone hills consist in part of hard yellowish to brownish gray calcareous sandstone or arenaceous limestone. The sandy component is largely the débris of acidic eruptive rocks of undetermined varieties. But it seems probable that the massive, calcite-seamed limestone and the gypsum occurring in the more westerly part of the same hills and across which Mr. Robert W. Goodell's section was taken, are closely associated and should be referred to the same formation with them; and if so the similar gypsums and massive limestones of Malone Mountain, described by Mr. Taff as the *Malone formation* (which in several respects the Goodell section duplicates), is a prominent part of that formation. For the formation, therefore, provisionally regarded as embracing the fossiliferous sandstones and limestones, the gypsums, the massive calcite-seamed limestones, and any other rocks included among these, of the Malone Mountain and the hills north and east of Malone Station, Mr. Taff's name *Malone beds*, or Malone formation is appropriately retained. The Malone formation thus assumes wider limits, a different age-significance, and far greater importance than were assigned to it by Mr. Taff. Yet to him belongs the credit of having published the first section from it, and of having called attention to the fact that the Malone uplift is older than other orographic features of the Sierra Blanca district.

The Geological Map of Mexico, published by the late Director of the Geological Survey of Mexico, Señor Castillo, shows a

limited area of Jurassic rocks in northern Mexico, not far southwest of Saltillo. This is apparently the nearest known occurrence of marine Jurassic rocks to that here announced, being distant from Malone some 500 miles in a southeasterly direction. The discovery of Jurassic rocks in El Paso county, Texas, therefore, raises the interesting question whether other limited areas of Jurassic may not yet be discovered in intermediate territory.

This article in major part, including definite reference of the fossiliferous beds of the Malone hills to the Jurassic upon evidence derived from the Trigonias of the Goodell collection, was first written in the latter part of 1896. Its publication was postponed, — with some revision of the manuscript in the meantime, — in the hope that I might soon visit the formation in person and secure more abundant data. This I was unable to do till August last. Reaching the vicinity on the nineteenth of the month, I spent about three weeks exploring some of the localities accessible from Sierra Blanca station, devoting principal attention to the Malone fauna and formation. The large collection of fossils made from the latter, so far as yet studied, confirms the reference to the Jurassic. I at first intended to incorporate the results of this trip with those derived from the Texas Survey and Goodell collections and data ; but it has seemed best to publish deductions from the earlier data without the further delay involved in the study of this season's material, and to present the results of the latter study, when completed, in separate articles.

When this article was first written, I did not have access to the first number of the Boletin de la Comision Geologica de Mexico, containing Castillo and Aguilera's "Fauna Fossil de la Sierra de Catorce," my copy of it having been temporarily lost in the exigencies of a change of residence. The missing document has since come to light, and the independent reference which I have made of the Malone fauna to the Jurassic, is confirmed by it, *Pleuromya inconstans* and *Lucina potosina* being apparently common to the Malone and the Alamitos ("upper Jurassic") formations (as elsewhere indicated in footnotes), and

the ornamentation of the Malone ammonite fragment apparently agreeing with that of the Alamitos form, *Hoplites bifurcatus*.

In conclusion, I regret to have to record the recent decease of Mr. Robert W. Goodell, which occurred at his home in Houghton, Michigan, on the 23d of September last, and in his 28th year. I regard his early calling away, not only as a personal bereavement, but as a distinct loss to science as well; for, though an invalid, and unable to bear the confinement involved in the elaboration of his out of door observations, he was a young man of unusual intellectual ability and promise and an enthusiastic and careful observer. He had done considerable field work on the Laramie, Denver, and Fort Union formations in the area between Denver and Colorado Springs, and on several other matters of Colorado, Texas and Michigan geology; and, as appears in the present article, it is to his zeal as a scientific explorer that we owe the trip to Malone which, aided by his father's more robust physical strength, resulted in the means for the first satisfactory diagnosis of the age of the Malone hills fauna; and in an important advance in our knowledge of the distribution of North American Jurassic rocks.

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